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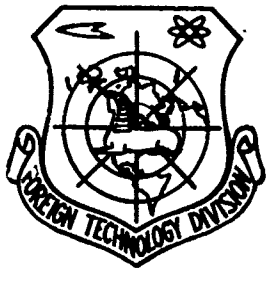
EXPERIMENTAL RESEARCH ON ARTIFICIALLY TRIGGERED LIGHTNING

By

Sya Yu-ren, Syau Ching-sya, et al



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EXPERIMENTAL RESEACH ON ARTIFICIALLY TRIGGERED LIGHTNING

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Lightning is an unusually impressive type of natural phenomenon; the calamities created by thunderstorms are familiar to everyone; because of this, lightning research, from ancient times on, has been a principal point of attention among scientific workers in China and abroad. At present, there is already data observing and measuring the capability of electric currents in lightning to reach several tens of thousands and even several hundreds of thousands of amperes,(1) at the same time producing huge amounts of power in the twinkling of an eye; the high temperatures produced by lightning can, on an average, reach from six thousand to thirty thousand degrees or more(2); the pressure of a lightning shock wave can reach two hundred atmospheres(3). Lightning can also produce ozone and manufacture nitrogen fertilizer(4); it can make plasma bodies; lightning is even able to produce neutrons(5). Lightning and convection cloud precipitation also have an extremely close relationship(6), therefore, research into lightning and its uses has an extremely bright future. However, concerning natural lightning, people have no way to predict beforehand at what time and what place lightning will occur; because of this, there is still a shortage of systematic and careful research into the organic substances lightning is capable of producing, some physical chemistry processes, etc. Artificially triggered lightning is one important method researching and utilizing lightning.

From Franklin on, people have researched various types of methods thinking to attract lightning; however, because numerous accidents occurred, this type of research was broken off in the middle to some degree. The modernized technique of artificially triggered lightning, according to the Frenchman Hubert(7), begins with the American Newman. In recent years, the United States, in order to protect spacecraft and aircraft as well as communications transmissions, has done research from theory to field testing on artificially triggered lightning. France's Nuclear Energy Committee and the French Electrical Instruments Company, because of the problem of protecting high tension lines, etc., also successfully carried out tests of artificially triggered lightning in 1973.(8) When we received the inspiration, which

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* Others who participated in this work are: Mwo Shr-min, Hwang De-feng, An Sywe-min, Reng Dung-sheng, Wang Dzai-ming and other comrades. During experimentation into rocket alignment, Comrades Dwun Chang-ming and Hwang Meng-rung rendered assistance.

the masses of Yunnan Province had observed, that, when lightning changes from horizontal to vertical, hailstones disappear, we then, taking several observed facts about the relation between lightning and precipitation as a basis, carried out initial theoretical discussions concerning the capability of cloud-to-ground lightning to eliminate hail,[6] recognizing that the use of artificially triggered lightning could answer the objectives of eliminating hail and artificially controlling precipitation. This being so, we launched experimentation into artificially triggered lightning in 1977.

1. Principles and Methods of Artificially Triggered Lightning

Naturally, lightning is a type of electrical discharge phenomenon in the atmosphere, and must produce the specific electric field strength required for electrical discharge phenomena, for example, under one atmosphere pressure, the discharge value for dry air is 30,000 volts/cm. In the same way, the formation of natural lightning also requires an adequate accumulated charge in the thunderheads, moreover, there must be a specific electric field value. Inside thunderheads or rainclouds with strong electic fields, when the value for the formation of natural lightning has not been reached, if it is possible to artificially increase the electric field to the critical value for the formation of lightning, then, it is possible to reach the objective of triggered lightning.

In that case, what method is there to artificially increase the electric field? Everyone knows that, according to Kasemir's calculations[9], the American Apollo rockets, when flying through clouds, have point electric fields increased 345 times over the original electric field in the clouds. Therefore, after the Apollo 12 spacecraft entered a raincloud having an electric field with a level of only 100 volts/cm, it then successively triggered two lightning flashes; this is what is known as "The Apollo 12 Lightning Incident." In accordance with the theory of Frenkel' [10], the point electric fields of long, thin earthing conductors is increased even more strongly. Labratory experiments also confirmed that thin conductors that are moving can trigger electrical discharges even more easily than can thin, stationary conductors. Because of this, if, under thunderhead conditions, there were a thin earthing conductor suddenly fired toward the clouds, the strong point electric field of the thin conductor at this time would make it very easy to cause the air to give rise to artificially triggered lightning produced by the penetration of the conductor. Therefore, no matter how the American or French techniques for causing thunder are modernized, their basic method still will be to trigger lightning by firing a 0.2mm diameter grounded thin steel wire of several hundred meters in length carried by a rocket toward clouds under thunderhead conditions.[7][8][10]

2. The Technical Implementation of Artificially Triggered Lightning

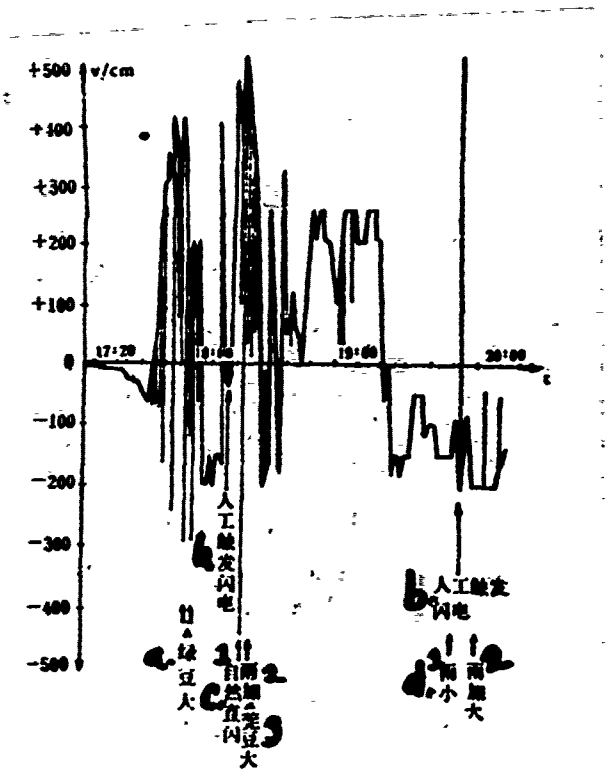
Our artificially triggered lightning technology is also of a type that triggers lightning by firing a thin, grounded conductor of several hundred meters length behind a rocket into thunder clouds. The differences between it and the American and French methods are that all rocket and line equipment is very simple, moreover, due to the employment of remote control ignition, we saved having complicated safety facilities, which facilitates its popularization and spread.

Rocket: The one we used was a small Type 40 rocket used to prevent hail; due to the lightning speed of flight of small rockets, it was possible to exceed the speed of sound; because of this, the conducter line was constantly pulled out to a distance of less than 100m and then broke; later, we employed weighted rocket nose cones to slow down the speed of flight, and we obtained relatively demonstrable results and solved the problem of the easy breaking of the conductor line.

Conductor Line and Its Installation: The outside diameter of the conductor line carried by the rocket is 0.5mm; its core is copper wire, and the outside of it is wrapped in nylon filaments to increase its tensile strength. A 500-1000m length of conductor line is rolled onto a dowel with a diameter of 15cm. When the rocket is launched, take the line dowel with the conductor line already wound onto it and put it in a position 1m from the gantry; use steel nails to fasten the center of the line dowel to the ground in order to avoid displacing or rolling the line dowel being pulled on and breaking the line. The end of the line under the line dowel and the ground line are connected (the ground is a copper plate buried approximately 1m deep in the ground) the other end of the steel wire is fastened to the body of the rocket (the object of using the steel wire is to prevent the high temperature gases expelled by the rocket from burning the thin conductor line in two).

Ignition: Due to the fact that, after the lightning is triggered, it will flow along the conductor line to the ground, people must not be in an area 10m around the rocket launch gantry[12] in order to protect their safety. Concerning rocket ignition, we employed remote control technology to do the manipulations from a long distance away; the remote control distance of the remote control device was 1 km; this was adequate for use as far as we are concerned.

Choice of Circumstances for Ignition: The circumstances for ignition of the rocket are very important to the triggering of lightning; to determine what time is most certain to bring a successful triggering of the lightning one must consider whether or not the main cloud mass has closely approached and passed through the triggering point. At the same time, one must use electric field instruments and lightning calculators to carry out observations, according to the experience of the French[8] and ourselves, when one observes a ground electric field strength greater than 200 volts/cm, carrying out rocket operations, it is relatively easy to obtain success in triggering lightning (see Fig 1).



a. large as green lentils b. Artificially Triggered Lightning
c. 1 Natural Vertical Lightning, 2 Additional Rain, 3 large as peas
d. 1 Small Rain, 2 larger Rain

Fig 1 Observation Record of Artificially Triggered Lightning and Ground Surface Electrical Field for 19 September 1977

3. The Status of Experimentation on Artificially Triggered Lightning

The location of our experiments was on a mountain top in the mountainous region of southern Ning-Sya, approximately 2200 m above sealevel. This mountainous area has conditions which produce clouds; there are also three thunderstorm tracks crossing this area. The average number of thunderstorm days each year is approximately 32, moreover, some thunderstorm days even have three instances of Cb cloud development processes. If the number of thunderstorms is large, obviously it is an advantageous condition for experiments on causing thunder.

Besides, the visual field of our experimental location was very wide, using the naked eye one could see clouds more than several tens of kilometers away, this was extremely advantageous for the early discovery of thunderstorms and the consequent completion of preparations for firing the rocket. Now we will take the circumstances of several instances of artificial triggering of lightning and introduce them separately as follows:

1. Circumstances of Triggered Lightning on 19 September 1977

On 19 September at 1700 hours approximately, straight north of the experimental location there was Cb cloud development; at 1739 hours the sound of thunder was heard; the main cloud mass reached the triggering point at about 1800 hours; at this time, the observed earth surface electric field had already reached -200 volts/cm; we began operations to carry out triggering the lightning. At 1943 hours, when the rocket pulled out approximately 350m of conductor line, lightning was triggered; electric field instruments recorded in this instance an electric field change from -200 volts/cm to +500 volts/cm (Fig 1). The path of the lightning in this instance was approximately 300m long; it traveled straight from air to earth; the top portion was forked; the path of the lightning was wide and bright; the sound of the thunder was just as fierce as that of lightning sent to earth by natural clouds. At the observation station approximately 300m from the triggering point, we used 120 cameras to photograph this occurance of lightning (see Fig 2). From the picture one can see a straight and wide luminous line; this is the conductor line emitting light as it burned when the lightning current passed through it; the other two bent, luminous, thin lines are two instances of the back-flash process.

2. Circumstances of Two Other Lightning Triggerings

On 17 September at 1550 hours and 10 seconds, the first instance of triggered lightning was a success; the electric field changed from +400 volts/cm to -200 volts/cm; the path of the lightning was approximately 50m long; the top portion was bright and wide; the bottom portion was dim and narrow; simultaneously, we heard a sound like a firecracker exploding.

On 19 September at 1806 hours and 35 seconds, there was an occurance of triggered lightning; the change in electric field was not great (from -30 volts/cm to -4 volts/cm); the path of the lightning was approximately 200m long; moreover, concerning the sparks which were produced after the conductor line was burned in two by the lightning current, these made a "pi pi pai pai" sound, floated in the air for about half a second and went out.

In these few successful artificial triggerings of lightning, not only did we see a lightning flash, hear the sound of thunder, record changes in the electric field and take photographs; moreover, it was also possible to see the traces made by the lightning current as it penetrated the conductor line which was not pulled off the line dowel. The conductor line which the rocket pulled out was burned to bits by the lightning current; the conductor line on the line dowel and grounded conductor line contact underwent the phenomenon of being burned apart.

3. The Circumstances of Hail and Precipitation after Lightning Triggering

After triggering the lightning, we observed whether it was capable of producing a precipitation "dumping" phenomenon in the same way natural lightning is, and within a few seconds after the lightning was triggered, without question, both hail and precipitation were suddenly increased. For example, on 17 September, before the lightning was triggered, the size of the hail was only 3-4mm; moreover, it was falling very sparsely; however, after the lightning was triggered, the size of the hail was 5-6mm; moreover, it was falling relatively heavily. To cite another example, on 19 September at 1943 hours lightning was triggered; it was raining lightly before the lightning; it was raining heavily after the lightning. Concerning this type of ability of artificially triggered lightning to produce a precipitation "dumping" phenomenon, it is certainly the basis for our using it to proceed with artificial precipitation and defense against hail; the rationale for this can be see in (6). The circumstances of the hailstorm of 17 September were that the area above the triggering point had heavy hail, the station itself had light hail, and the area below it experienced slight amounts of hail or none at all. Because of the lack of exact scientific data, we cannot assert that this is the result of artificially triggered lightning; however, using artificially triggered lightning to proceed with theoretical research and experimentation into artificial precipitation and defense against hail is most certainly a problem worthy of study hereafter.

Concerning experimentation into artificially triggered lightning, for research into and the utilization of lightning, including the aspects of artificial control of lightning, artificial precipitation and particularly defense against hail, we have provided one productive path for research. Besides this, our work can also offer a new type of technology for the protection of atomic energy and high-tension lines, etc. Although the utilization of lightning inside China and abroad is still in its initial stage, its future is still ahead of it; we firmly believe that the day will certainly come when lightning will obtain broad utilization for mankind.

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Fig 2 Photograph of Artificially Triggered Lightning. Taken 19 Septemb[illegible]7 at 1943 Hours.

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